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ABSTRACT

The effect of dimensional training on the mode of response of kindergarten children to two-dimensional stimulus materials was investigated by Kruskal-Shepard scaling and Procrustes rotation procedures. Twenty-two kindergarten children were used as Ss. The stimuli consisted of five cardboard rectangles varying on two dimensions of colour and size. From the five stimuli, ten triads were formed and presented to the Ss for similarity judgments. After training, the procedure was repeated. In the pre-training stage it was found that Ss were not dimensionalizing fully whilst in the post-training stage difficulties of interpretation resulted owning to what appeared to be individual styles. (Author)

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USE OF SCALING TECHNIQUES IN THE ANALYSIS OF MODE OF RESPONDING OF KINDERGARTEN CHILDREN[1]

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The contemporary approach to discrimination learning rests heavily on mediating mechanisms. The two main types of mediators proposed are attentional in nature (Zeaman & House, 1963; Lovejoy, 1968) and verbal in nature (Kendler & Kendler, 1962). The developmental theory of discrimination learning, as advanced by the Kendlers (Kendler & Kendler, 1962), has been criticized on various accounts (Wolff, 1967). In contrast, Tighe and Tighe (1966), advocate differentiation theory to explain the developmental trends in discrimination learning. Basically the difference in approach is the difference exhibited between an associative learning model and a perceptual learning model. Differentiation theory states:

> ...the fundamental process in the development of discrimination is not the enrichment or modification of stimuli as in a mediation process, but one of differentiation of the stimulus array, that is, of coming to see more of what is present in stimulation (Tighe & Tighe, 1966).

The relative ability to perform intradimensional and extradimensional shifts, according to differentiation theory, rests on the S's perceptual development. This level of perceptual development will be the deciding factor of whether the S is responding to the stimuli as undifferentiated wholes or

whether he is able to distinguish the dimensions independently of one another (Tighe & Tighe, 1968). Wolff (1967) criticizes differentiation theory by pointing out that almost all Ss regardless of age, tend to dimensionalize the stimuli at the outset of the concept shift task. Tighe and Tighe suggest that prediscrimination preference tasks may 'not only reveal selective responses to aspects of the stimulus situation but also instate or augment such selective responses (Tighe et al, 1970).' This facilitating effect of perceptual pre-training on the outcome of concept discrimination learning of young Ss has been demonstrated by Tighe & Tighe (1968).

The problem of whether young Ss are responding to stimuli by isolating the relevant distinguishing features, or whether they are responding by distinguishing the stimulus objects on a basis of combined values of the dimensions, can be investigated not only from an examination of the responses of the Ss in a discrimination task, but also from an examination of the scaling techniques used by children when confronted with a scaling problem involving these stimuli. If stimuli are constructed such that a theoretical scaling outcome can be advanced based on whether S has scaled on one, or all dimensions of the stimuli, then an examination of the scaling results before and after dimensional training should give some indication of the mode of scaling responses used by S.

The present study was designed to examine the feasibility of using scaling techniques to investigate the effect of dimensional training on the responses of young Ss.

METHOD

Sample Twenty-two kindergarten children (9 females and 13 males) were used in the study with a mean chronological age of 5.7 years.

Materials The stimulu material consisted of five cardboard rectangles which varied on the dimensions of colour and size (width constant). The size of the rectangles were: 4 1/2 X 6 inches; 4 1/2 X 3 inches; 4 1/2 X 1 1/2 inches. The colours of the rectangles were black, grey and white as defined by the Colour Swatch Book (1962). The coloured rectangles were chosen to fit a two-dimensional space, as shown in Figure 1, with stimulus C standing at the mid-point of the size and the colour dimensions.

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Insert Figure 1 about here

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The mid-point of the size dimension was obtained by direct measurement and the mid-point of the colour dimension was obtained by taking the median value of grey chosen by an independent sample of 18 kindergarten children as falling half-way between the given black and white. This value of grey was found to be Grey 7. From the five stimulus cards, 10 triads were formed (${}_5C_3$).

Procedure The 10 stimulus triads were presented in the same random order to the children, individually, on a neutral background. These children were asked to pick the two cards which were most alike and the two cards which were most different for each triad. The task was repeated the following morning immediately following a training period with each child. The training period consisted of asking each child to arrange the stimuli in order of size and then arrange in

order of colour. The E named the dimensions and established with each child the fact that the stimuli differed on two dimensions. When E was confident that each child was aware of these distinctions, the second scaling task took place.

ANALYSIS AND RESULTS

From each of the similarity-difference responses made by each subject, three relationships can be deduced. For example if D was judged most like B, and B judged most different from E, then from these judgments three deductions can be made. D is more like B than D is like E; B is more like D, than B is like E; and E is more like D than E is like B. From the total deductions for all the triads, five matrices were constructed, where an element of each matrix was the number of times stimulus k was judged more similar to stimulus i than stimulus k was judged similar to stimulus j. From these five matrices a matrix of similarities was obtained from the pre- and post-training responses. These similarity matrices are given in Tables 1 and 2. Three additional similarity matrices were obtained based on error-free judgments of the triads. These

Insert Tables 1 and 2 about here

judgments were first based on the dimension of colour, then on the dimension of size and then on both dimensions. The total five matrices, each in turn, became the input matrices for the Kruskal-Shepard (1964a, 1964b) scaling procedure and the scaled values of the empirical and error-free responses were thus obtained.

The Kruskal-Shepard scaling technique consists of fitting a configuration of data points into a dimensional space such that the final configuration best reflects the rank order of the original data points. The stress of the final configuration, defined in terms of the departure of the best fitting configuration from the original configuration in a space of least dimensions, is a measure of the success of the fit. The Kruskal-Shepard method assumes no underlying distance function model. Because of this non-metric approach, the technique can be applied directly to any measure of relationship between stimuli as long as the user feels justified that the measures are a reflection of the underlying distances between the stimuli. The problem of 'local minimum' was partially solved by running the programme many times using different initial configuations and taking the scaled values of the run with the lowest stress as the 'best' values. Table 3 shows the <u>stress</u> values for the pre- and post-training data and Table 4 the <u>stress</u> values for the theoretical data for a one and two dimensional fit respectively. The option in the Kruskal-Shepard scaling procedure of scaling within a City-Block space (Attneave, 1950), or a Euclidean space, was also used on the assumption that the scaled values of children judging on dimensionalized stimuli best fit the City-Block model, whilst those of children judging at an undimensionalized level best fit the Euclidean model.

Insert Tables 3 and 4 about here

The scaled values obtained from the Kruskal-Shepard scaling procedure were rotated to a theoretical target matrix by the Schonemann and Carroll Orthogonal Procrustes Rotation procedure (Schonemann & Carroll, 1970). This method fits one matrix to another matrix by rotation, translation, and dilation in the least square sense and produces a <u>normalized symmetric error</u> as the index of

best fit. The error matrix is the matrix obtained by subtracting the values of the final best-fit matrix from the values of the target matrix. Tables 5 and 6 give the normalized symmetric errors for the pre- and post-training results and the error-free data respectively.

Insert Tables 5 and 6 about here

DISCUSSION

This study proposed to examine the feasibility of using scaling techniques to investigate the effect of dimensional training on the responses of young Ss. By an investigation of the method of responding to stimuli, varying on more than one dimension, it was hoped that more light could be thrown on the method used by children in a discrimination task. The problem of whether young children respond to the stimuli as 'undifferentiated wholes', or whether they dimensionalize the stimuli from the outset, is a fundamental issue in discrimination learning. The present study has not solved this problem, but has shown the worthwhileness of using scaling techniques in such situations.

From Table 3 it can be seen that the pre-training similarity matrix data fits a two-dimensional space better than a one-dimensional space for both models. Kruskal (1964a) gave the following departures from perfect stress as a measure of success of fit: .025 - excellent; .05 - good; .10 - fair. Klahr (1969), pointed out that the Kruskal technique is very sensitive to the number of stimulus points and the dimensions used in the fit. As this study is concerned with how better one set of points fits a given dimensional space better than how another set of points fits the same dimensional space we are safe to compare stress within a dimensional space but cross dimensional space stress

comparisons must be interpreted with care.

Table 5 shows, however, that the rotation of the scaled values in one dimension to a target of one-dimensional values was better than the rotation of the two-dimensional scaled values to a two-dimensional target. In particular, the rotation to the dimension of size was far better than the rotation to the dimension of colour, the latter being as poor as the poorest rotation obtained with error-free data. From these results it would appear that the Ss in the pre-training stage were not dimensionalizing the stimuli completely, the tendency being to judge more on the dimension of size than colour.

The results given in Table 3 indicate that the post-training similarity matrix fits a two-dimensional space better than a one-dimensional space in the Euclidean model. In the City-Block model the fit is poor in both the one- and two-dimensional space. Furthermore, the fit in two-dimensional space is better for the Euclidean model than the City-Block model. On the assumption made earlier in the paper, this analysis would suggest that children in the post-training stage were responding at an undimensionalized level also, and not at a dimensionalized level as one would suppose due to the dimensional training. This conclusion is not completely substantiated in Table 5, however, where it is seen that the respective scaled values in the post-training stage in Euclidean space, when rotated to a theoretical target, give a poor fit in not just a one-, but also a two-dimensional space. The latter result can be partially explained when it is noted that in the original data matrix many children after training were inconsistent in responding within a dimension, i.e., within the dimension of size, large was more similar to large than small was to small and similarly black was more similar to black than white to white. These cognitive styles, when taken as a group, give rise to complications in the mode of responses which makes a clear interpretation difficult when an

individual model is not used.

The apparent non-effect of dimensional training on children's responses could be partly explained by the nature of the task involved. Similarity-difference judgments of themselves could call for responding at an undifferentiated whole level unlike discrimination tasks in which the process is one of isolating the relevant cue. This fact, linked with the individual cognitive styles mentioned above, would compound the results.

The method of triadic combinations used in this study proved to be highly satisfactory for young Ss, and the scaling techniques employed for the analysis of the data seemed to yield interpretable results. Further studies using similar scaling techniques with Ss at varying age levels could provide developmental information on stimuli differentiation. The results of such studies could then be linked with the large body of developmental discrimination theory.

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FOOTNOTES

[1] Paper presented at the American Educational Research Association, New Orleans, 1973.

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TABLE 1

Frequency Matrix Where Each Element is Equal to the Number of Times i Was Judged More Similar to j than Any Other Stimuli in the Pre-Training Stage

				j		
		A	B	C	D	E
	A	-	100	73	35	61
	B		-	65	54	57
i	C			-	46	70
	D				-	99
	E					-

TABLE 2

Frequency Matrix Where Each Element is Equal to the Number of Times i Was Judged More Similar to j Than Any Other Stimuli in the Post-Training Stage

		j				
		A	B	C	D	E
	A	-	103	77	18	71
	B		-	60	87	40
i	C			-	47	63
	D				-	94
	E					-

TABLE 3

Kruskal-Shepherd Stress Values Using Pre-Training and Post-Training Data

		Pre-Training		Post-Training	
Dimensional Space Used	1	.21[a]	(.38)[b]	.59[a]	(.54)[b]
	2	.00[a]	(.01)[b]	.01[a]	(.32)[b]

a. Euclidean model

b. City Block model

TABLE 4

Kruskal-Shepard Stress Values Using Error-free Data

Number of dimensions used in Kruskal-Shepard fit

		1 dimension	2 dimensions
Number of dimensions used in theoretical scaling	1 (colour)	.00	.00
	(size)	.00	.00
	2	.41	.00

TABLE 5

Normalized Symmetric Error Using Orthogonal Procrustes Rotation Factor Match for Empirical Scaled Values

		Pre-Training	Post-Training
Dimensional Space Used	1 (colour)	.87	.89
	(size)	.10	.53
	2	.29	.43

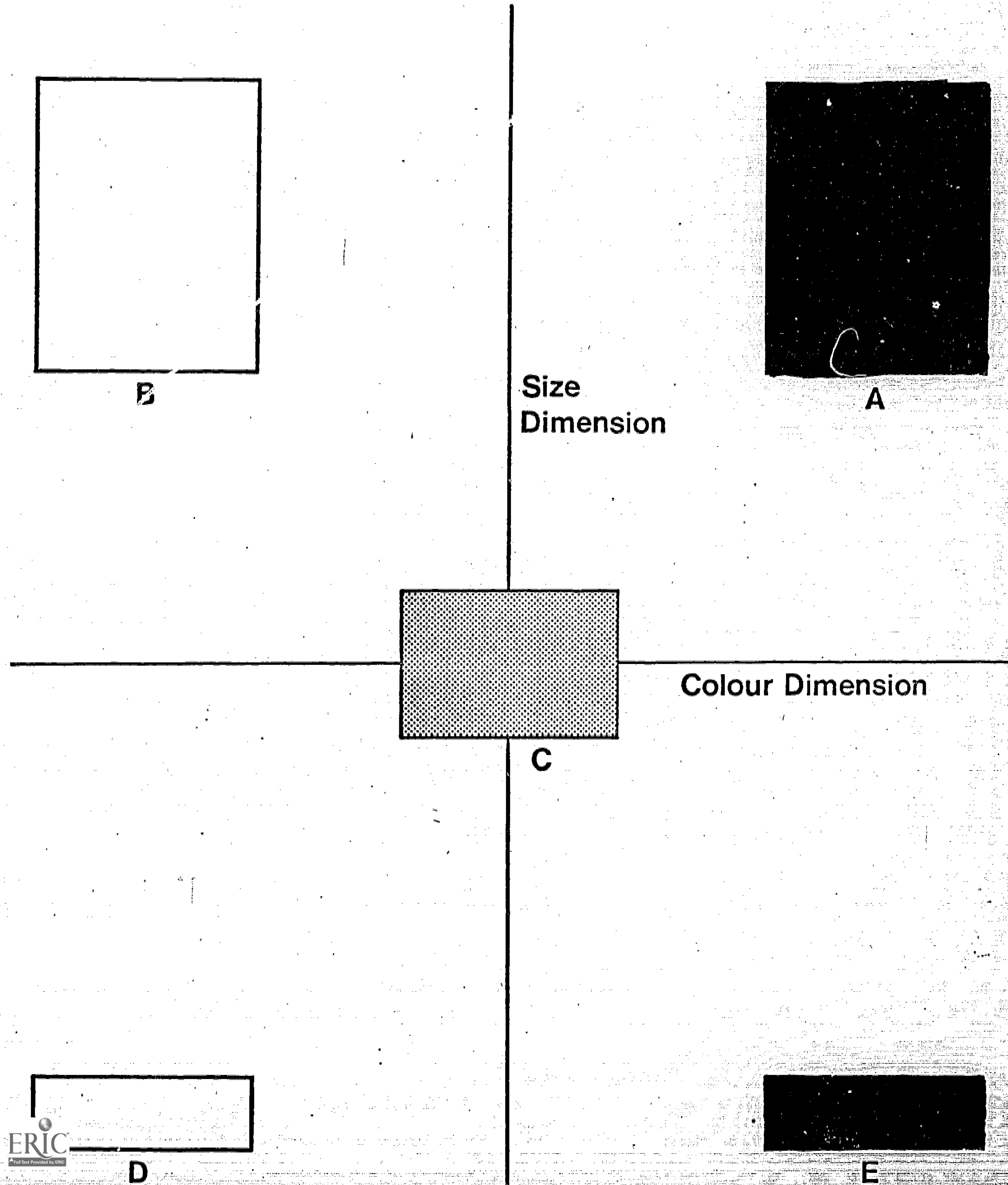
TABLE 6

Normalized Symmetric Error Using Orthogonal Procrustes Rotation
Factor Match for Error-free Scaled Values

		Number of dimensions rotated to:	
		1	2
Number of dimensions used in theoretical scaling	1 (colour)	.05 (colour) .89 (size)	.33
	2	.89	.03

FIGURE LEGEND

Fig. 1 -- Two-dimensional stimuli space


B
A
Size
Dimension
Colour Dimension
C
D
E